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(71) Applicant: **F. HOFFMAN-LA ROCHE AG [CH/CH]**;  
124 Grenzacherstrasse, CH-4070 Basle (CH).

(72) Inventors: **LESER-REIFF, Ulrike**; Weidenweg 6, 82377  
Penzberg (DE). **SATTELKAU, Tim**; Renzstrasse 1, 68161  
Mannheim (DE). **ZIMMERMANN, Gerd**; Rheinstrasse  
9A, 76351 Linkenheim (DE).

(74) Agent: **SCHREINER, Siegfried**; Roche Diagnostics  
GmbH, Patent Department (TR-E), P.O. Box 11 52, 82372  
Penzberg (DE).

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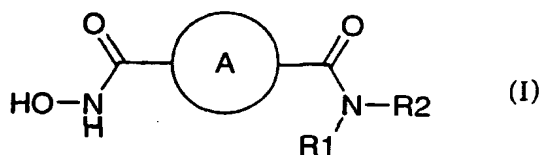
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(54) Title: **AROMATIC DICARBOXYLIC ACID DERIVATIVES**



(57) Abstract: Compounds of formula (I) wherein A, R<sub>1</sub> and R<sub>2</sub> have the meanings defined in the specification, process of manufacturing these compounds and medicaments with HDAC inhibitor activity containing such a compound.

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## AROMATIC DICARBOXYLIC ACID DERIVATIVES

The invention relates to aromatic dicarboxylic acid derivatives, or pharmaceutically-acceptable salts thereof, which possess anti-cell-proliferation activity such as anti-cancer activity and are accordingly useful in methods of treatment of the human or animal body. The invention also relates to processes for the manufacture of said dicarboxylic acid derivatives, to pharmaceutical compositions containing them and to their use in the manufacture of medicaments of use in the production of an anti-cell-proliferation effect in a warm-blooded animal such as man.

### Background of the Invention

Transcriptional regulation is a major event in cell differentiation, proliferation, and apoptosis. Transcriptional activation of a set of genes determines cell destination and for this reason transcription is tightly regulated by a variety of factors. One of its regulatory mechanisms involved in the process is an alteration in the tertiary structure of DNA, which affects transcription by modulating the accessibility of transcription factors to their target DNA segments. Nucleosomal integrity is regulated by the acetylation status of the core histones. In a hypoacetylated state, nucleosomes are tightly compacted and thus are nonpermissive for transcription. On the other hand, nucleosomes are relaxed by acetylation of the core histones, with the result being permissiveness to transcription. The acetylation status of the histones is governed by the balance of the activities of histone acetyl transferase (HAT) and histone deacetylase (HDAC). Recently, HDAC inhibitors have been found to arrest growth and apoptosis in several types of cancer cells, including colon cancer, T-cell lymphoma, and erythroleukemic cells. Given that apoptosis is a crucial factor for cancer progression, HDAC inhibitors are promising reagents for cancer therapy as effective inducers of apoptosis (Koyama, Y., et al., Blood 96 (2000) 1490-1495).

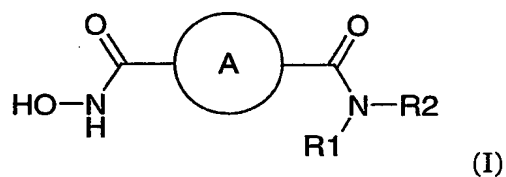
Several structural classes of HDAC inhibitors have been identified and are reviewed in Marks, P.M., et al., J. Natl. Cancer Inst. 92 (2000) 1210-1216. More specifically, WO 98/55449 and US 5,369,108 report alkanoyl hydroxamates with HDAC inhibitory activity.

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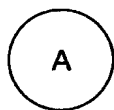
It has now been found that certain aromatic dicarboxylic acid derivatives possess anti-cell-proliferation properties which are more potent than those in the aforementioned references. Furthermore, these compounds have HDAC inhibitory activity.

## 5 Description of the Invention

According to the invention there is provided an aromatic dicarboxylic acid derivative of the formula I



wherein

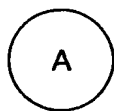


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denotes a phenyl ring which may be unsubstituted or substituted by 1, 2 or 3 substituents independently selected from a halogen atom, an (1-4C)alkyl-, trifluoromethyl-, hydroxy-, (1-4C)alkoxy-, nitro-, amino-, (1-4C)alkylamino-, di[(1-4C)alkyl]-amino-, (1-4C)alkanoylamino, a (1-3C)alkylenedioxy-group or an acyl group,

15

or



20

denotes or a thiophene ring which may be unsubstituted or substituted by 1 or 2 substituents independently selected from a halogen atom, an (1-4C)alkyl-, trifluoromethyl-, hydroxy-, (1-4C)alkoxy-, nitro-,

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amino-, (1-4C)alkylamino-, di[(1-4C)alkyl]-amino- or a (1-4C)alkanoylamino, a (1-3C)alkylenedioxy-group or an acyl group,

and

R1 and R2 are the same or different from each other and are

- 5 a hydrogen atom;  
a branched or unbranched (1-14C)alkyl group, which  
may be unsubstituted or substituted with 1 or several substituents  
independently selected from the group consisting of a halogen-, hydroxy-,  
nitro-, amino-, carbocyclic- or a heterocyclic group,  
10 and wherein at a chain length of larger than 2 C-atoms one or several non  
adjacent C-atoms may be replaced by a corresponding number of heteroatoms  
such as oxygen, nitrogen or sulfur,  
and wherein 2 C-atoms may be bound together by a double or triple bond;  
a carbocyclic group;  
15 or a heterocyclic group;

- or R1 and R2 together with the nitrogen atom form a 3-6 membered ring which  
may contain additional heteroatoms independently selected from nitrogen, oxygen  
and sulfur, and which may be annulated by a carbocyclic group or by a heterocyclic  
20 group and which may be unsubstituted or substituted by 1, 2, or 3 substituents  
independently selected from a halogen atom, an (1-4C)alkyl-, trifluoromethyl-,  
hydroxy-, (1-4C)alkoxy-, aryl-, hetaryl-, arylalkyl, arylalkyloxy-, aryloxy, (1-  
3C)alkylenedioxy-, nitro-, amino-, (1-4C)alkylamino-, di[(1-4C)alkyl]amino-, (1-  
4C)alkanoylamino- or an acyl-group.

- 25 An alkyl group may be e.g. pentyl, hexyl or 3-methyl-butyl.

A substituted alkyl group may be e.g. benzyl, phenethyl, tetrahydro-furan-2-yl-  
methyl or 2-cyclohex-1-enyl-ethyl.

- An alkyl group where one or several non adjacent atom groups may be replaced by  
oxygen, nitrogen or sulfur atoms may be e.g. 3-isopropoxy-propyl or 2-  
30 methylsulfanyl-ethyl.

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An alkyl group wherein 2 atoms may be bound together by a double or triple bond may be e.g. 1-hexinyl or 2-heptenyl.

A carbocyclic group may be

5 a non-aromatic ring system with 3-7 carbon atoms, for example cyclopentane, cyclohexane, cyclohexene or cyclopropane, which may be unsubstituted or substituted by 1, 2, or 3 substituents independently selected from a halogen atom, an (1-4C)alkyl-, trifluoro-methyl-, hydroxy-, (1-4C)alkoxy-, aryl-, hetaryl-, arylalkyl, arylalkyloxy-, aryloxy, (1-3C)alkylenedioxy-, nitro-, amino-, (1-4C)alkylamino-, di[(1-4C)alkyl]amino-, (1-4C)alkanoylamino- or an acyl - group, and which may be annelated by an aryl or hetaryl group, to form e.g. an indane or a tetraline,

or it may be an aryl group.

15 An aryl group is a carbocyclic conjugated ring system, for example phenyl, naphthyl, preferably phenyl, which may be unsubstituted or substituted by 1, 2, or 3 substituents independently selected from a halogen atom, an (1-4C)alkyl-, trifluoromethyl-, hydroxy-, (1-4C)alkoxy-, arylalkyloxy-, aryloxy, (1-3C)alkylenedioxy-, nitro-, amino-, (1-4C)alkylamino-, di[(1-4C)alkyl]amino-, (1-4C)alkanoylamino-, carboxyl-, carboxyalkyl- or an acyl - group.

A heterocyclic group may be

20 a non-aromatic ring system with 3-7 members and one or two hetero atoms independently chosen from nitrogen, oxygen, and sulfur, for example piperidino, morpholino, pyrrolidino, piperazino, which may be unsubstituted or substituted by 1, 2, or 3 substituents independently selected from a halogen atom, an (1-4C)alkyl-, trifluoro-methyl-, hydroxy-, (1-4C)alkoxy-, aryl-, hetaryl-, arylalkyl, arylalkyloxy-, aryloxy, (1-3C)alkylenedioxy-, nitro-, amino-, (1-4C)alkylamino-, di[(1-4C)alkyl]amino-, (1-4C)alkanoylamino, or an acyl - group, and which may be annelated by an aryl or hetaryl group, to form e.g. a tetrahydroquinoline, tetrahydroisochinoline or a dihydroindole,

or it may be a hetaryl group.

5 A hetaryl group is either a 5 or 6 membered cyclic conjugated ring system with one or two hetero atoms independently chosen from nitrogen, oxygen, and sulfur, for example pyridinyl, thiophenyl, furyl or pyrrolyl, or an annulated bicyclic conjugated ring system like indolyl-, quinolyl- or isoquinolyl-, which may be unsubstituted or substituted by 1, 2, or 3 substituents independently selected from a halogen atom, an (1-4C)alkyl-, trifluoromethyl-, hydroxy-, (1-4C)alkoxy-, arylalkyloxy-, aryloxy, (1-3C)alkylenedioxy-, nitro-, amino-, (1-4C)alkylamino-, di[(1-4C)alkyl]amino-, (1-4C)alkanoylamino, or an acyl group.

10 When R1 and R2 together with the nitrogen atom form a 3-6 membered ring which may contain additional heteroatoms independently selected from nitrogen, oxygen and sulfur, it may be e.g. piperidine, piperazine or morpholine.

15 A suitable value for a substituent when it is a halogen atom is, for example, fluoro, chloro, bromo and iodo; when it is (1-4C)alkyl is, for example, methyl, ethyl, propyl, isopropyl, butyl, isobutyl, sec-butyl; when it is (1-4C)alkoxy is, for example, methoxy, ethoxy, propoxy, isopropoxy or butoxy; when it is (1-4C)alkylamino is, for example, methylamino, ethylamino or propylamino; when it is di-[(1-4C)alkyl]amino is, for example, dimethylamino, N-ethyl-N-methylamino, diethylamino, N-methyl-N-propylamino or dipropylamino; when it is (1-4C)alkanoylamino is, for example, formylamido, acetamido, propionamido or butyramido; when it is (1-3C)alkylenedioxy is, for example, methylenedioxy, ethylenedioxy or propylenedioxy; and when it is acyl is, for example, formyl, acetyl, propionyl, benzoyl, or phenylacetyl.

20 In a preferred embodiment, R1 is hydrogen and R2 has one of the above values. In a more preferred embodiment, R2 is a (1-14C)alkyl group. Most preferably, R2 is an arylalkyl – radical, for example the benzyl – radical or substituted benzyl – radicals.

25 Preferred are compounds wherein A denotes a thiophene ring. Even more preferred are compounds in wherein this thiophene ring is unsubstituted. Most preferred are compounds wherein two carboxylic moieties are bond at positions 2 and 5 of a further unsubstituted thiophene ring. Enantiomers, diastereoisomers, racemates and mixtures thereof and pharmaceutically acceptable salts of aromatic dicarboxylic acid derivatives of the formula I are also part of the invention.

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According to a further aspect of the invention there is provided a pharmaceutical composition which comprises an aromatic dicarboxylic acid derivative of the formula I, or a pharmaceutically-acceptable salt thereof, as defined hereinbefore in association with a pharmaceutically-acceptable diluent or carrier. The composition may be in a form suitable for oral administration, for example as a tablet or capsule, for parenteral injection (including intravenous, subcutaneous, intramuscular, intravascular or infusion) as a sterile solution, suspension or emulsion, for topical administration as an ointment or cream or for rectal administration as a suppository. In general the above compositions may be prepared in a manner using conventional excipients. The aromatic dicarboxylic acid derivative will normally be administered to a warm-blooded animal at a unit dose within the range 5-5000 mg per square meter body area of the animal, i.e. approximately 0.1-100 mg/kg, and this normally provides a therapeutically-effective dose. A unit dose form such as a tablet or capsule will usually contain, for example 1-250 mg of active ingredient. Preferably a daily dose in the range of 1-100 mg/kg is employed. However the daily dose will necessarily be varied depending upon the host treated, the particular route of administration, and the severity of the illness being treated. Accordingly the optimum dosage may be determined by the practitioner who is treating any particular patient.

According to a further aspect of the present invention there is provided an aromatic dicarboxylic acid derivative of the formula I as defined hereinbefore for use in a method of treatment of the human or animal body by therapy. It has now been found that the compounds of the present invention possess anti-cell-proliferation properties which are believed to arise from their histone deacetylase inhibitory activity. Accordingly the compounds of the present invention provide a method for treating the proliferation of malignant cells. Accordingly the compounds of the present invention are expected to be useful in the treatment of cancer by providing an anti-proliferative effect, particularly in the treatment of cancers of the breast, lung, colon, rectum, stomach, prostate, bladder, pancreas and ovary. It is in addition expected that a derivative of the present invention will possess activity against a range of leukemias, lymphoid malignancies and solid tumors such as carcinomas and sarcomas in tissues such as the liver, kidney, prostate and pancreas.

Thus according to this aspect of the invention there is provided the use of an aromatic dicarboxylic acid derivative of the formula I, or a pharmaceutically-acceptable salt thereof, as defined herein in the manufacture of a medicament for

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use in the production of an anti-cell-proliferation effect in a warm-blooded animal such as a human being.

According to a further feature of this aspect of the invention there is provided a method for producing an anti-cell-proliferation effect in a warm-blooded animal, such as man, in need of such treatment which comprises administering to said animal an effective amount of an aromatic dicarboxylic acid derivative as defined hereinbefore.

The anti-cell-proliferation treatment defined hereinbefore may be applied as a sole therapy or may involve, in addition to the aromatic dicarboxylic acid derivative of the invention, one or more other anti-tumor substances, for example those selected from, for example, mitotic inhibitors, for example vinblastine; alkylating agents, for example cis-platin, carboplatin and cyclophosphamide; inhibitors of microtubule assembly, like paclitaxel or other taxanes; antimetabolites, for example 5-fluorouracil, capecitabine, cytosine arabinoside and hydroxyurea, or, for example, intercalating antibiotics, for example adriamycin and bleomycin; immunostimulants, for example trastuzumab; DNA synthesis inhibitors, e.g. gemcitabine; enzymes, for example asparaginase; topoisomerase inhibitors, for example etoposide; biological response modifiers, for example interferon; and anti-hormones, for example antioestrogens such as tamoxifen or, for example antiandrogens such as (4'-cyano-3-(4-fluorophenylsulphonyl)-2-hydroxy-2-methyl-3'-(trifluoromethyl)-propionanilide, or other therapeutic agents and principles as described in, for example, Cancer: Principles & Practice of Oncology, Vincent T. DeVita, Jr., Samuel Hellmann, Steven A. Rosenberg; 5th Ed., Lippincott-Raven Publishers 1997. Such conjoint treatment may be achieved by way of the simultaneous, sequential or separate dosing of individual components of the treatment. According to this aspect of the invention there is provided a pharmaceutical product comprising an aromatic dicarboxylic acid derivative of the formula I as defined hereinbefore and an additional anti-tumor substance as defined hereinbefore for the conjoint treatment of cancer.

Another object of the present invention are pharmaceutical compositions containing a pharmacologically effective amount of one or more compounds of formula I in admixture with pharmaceutically acceptable excipients and/or diluents.



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Examples for physiologically acceptable salts of compounds of formula I are salts with physiologically acceptable bases. These salts can be, among others, alkali, earth alkali, ammonium and alkylammonium salts, for example sodium, potassium, calcium, tetra-methyl-ammonium salts.

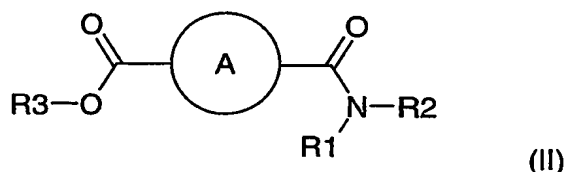
- 5 The separation of racemic compounds into their enantiomers can be performed by chromatography on an analytical, semipreparative or preparative scale using suitable optically active stationary phases with suitable eluents. Suitable optically active stationary phases include, but are not limited to, silica (e.g. ChiraSper, Merck; Chiralpak OT/OP, Baker), cellulose esters or carbamates (e.g. Chiracel OB/OY, 10 Baker) or others (e.g. Crownpak, Daicel or Chiracel OJ-R, Baker). Other methods for the separation of enantiomers can also be applied, like the formation of diastereomeric compounds from compounds of the formula I together with other optically active compounds, e.g. camphorsulfonic acid or brucin, and separation of these diastereomeric compounds, followed by the liberation from the optically 15 active agent. Enantiomerically enriched or pure compounds of formula I are also obtainable by the usage of optically active starting materials.

#### Preparation of the Compounds of the Invention

- 20 An aromatic dicarboxylic acid derivative of the formula I, or a pharmaceutically-acceptable salt thereof, may be prepared by any process known to be applicable to the preparation of chemically-related compounds. Such processes, when used to prepare an aromatic dicarboxylic acid derivative of the formula I, or a pharmaceutically-acceptable salt thereof, are provided as a further feature of the invention and are illustrated by the following representative examples in which, 25 unless otherwise stated, A, R1 and R2 have any of the meanings defined hereinbefore. Necessary starting materials may be obtained by standard procedures of organic chemistry. The preparation of such starting materials is described within the accompanying non-limiting examples. Alternatively necessary starting materials are obtainable by analogous procedures to those illustrated which are within the ordinary skill of an organic chemist.

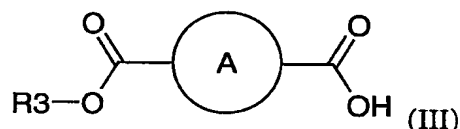
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(a) One preferred method for the production of compounds of the formula I involves the reaction of compounds of the formula II



5 wherein A, R1 and R2 have the meaning defined hereinbefore and R3 is a (1-4C)alkyl group, preferably a methyl or ethyl group, with hydroxylamine in the presence of a suitable base. The reaction is carried out in an inert solvent or diluent such as methanol or ethanol at temperatures between 0°C and 100°C, conveniently at or near ambient temperature, and at a pH between 10 and 12. A suitable base is, for example, an alcoholate, for example, sodium methylate.

10 Compounds of formula II are prepared from compounds of the formula III wherein A and R3 have the meaning defined hereinbefore.



15 This reaction typically involves a two-step one-pot procedure. In the first step, the carboxylate of the formula III becomes activated. This reaction is carried out in an inert solvent or diluent, for example, in dichloromethane, dioxane, or tetrahydrofuran, in the presence of an activating agent. A suitable reactive derivative of an acid is, for example, an acyl halide, for example an acyl chloride formed by the reaction of the acid and an inorganic acid chloride, for example thionyl chloride; a mixed anhydride, for example an anhydride formed by the reaction of the acid and a chloroformate such as isobutyl chloroformate; an active ester, for example an ester formed by the reaction of the acid and a phenol such as pentafluorophenol; an active ester formed by the reaction of the acid and N-hydroxybenzotriazole; an acyl azide, for example an azide formed by the reaction of the acid and an azide such as diphenylphosphoryl azide; an acyl cyanide, for example a cyanide formed by the reaction of an acid and a cyanide such as diethylphosphoryl cyanide; or the product of the reaction of the acid and a

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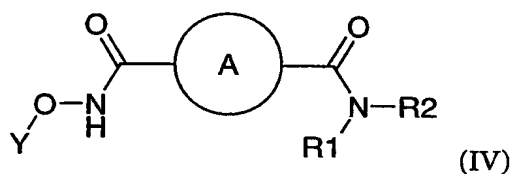
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carbodiimide such as dicyclohexylcarbodiimide, or the product of the reaction of the acid and bis-(2-oxo-3-oxazolidinyl)-phosphorylchloride. The reaction is carried out between -30°C and 60°C, conveniently at or below 0°C. In the second step, an amine of the formula HNR<sub>1</sub>R<sub>2</sub> in which R<sub>1</sub> and R<sub>2</sub> have the meaning defined  
5 hereinbefore is added to the solution, at the temperature used for the activation, and the temperature is slowly adjusted to ambient temperature. An appropriate scavenger base like e.g. triethylamine, or diisopropylethylamine may be added to the reaction mixture. These methods are well known to those skilled in the art. In principle, all methods for the synthesis of amides as used in peptide chemistry as  
10 described in e.g. "Methoden der organischen Chemie (Houben-Weyl)" Vol. XV/1 and XV/2 are also applicable.

There are quite a few compounds of formula III described in the literature. For example, the prototypic terephthalic monomethylester is described by, e.g., Holba, V., et al., Z. Phys. Chem.(Leipzig) 262 (3) (1981) 445-448. It is also commercially  
15 available. Thiophene-2,5-dicarboxylic acid monomethyl ester is described in e.g. US 2,680,731. These monoesters are usually prepared by selective saponification of the diester, but other method may be useful as well and are well known to those skilled in the art.

(b) Another preferred method for the preparation of compounds of the formula I is the deprotection of compounds of the formula IV  
20



wherein Y is a suitable protecting group and A, R<sub>1</sub> and R<sub>2</sub> have the meaning defined hereinbefore.

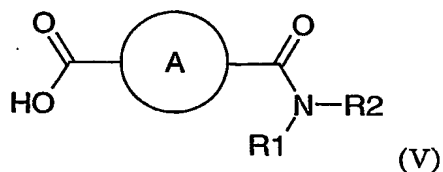
Compounds of the formula IV are new and included in the present invention.

25 Suitable protecting groups may be the benzyl-, p-methoxybenzyl-, tert.butyloxycarbonyl-, trityl-, or silyl groups such as the trimethylsilyl- or dimethyl-tert.butylysilyl-group. The reactions carried out depend on the type of the protecting group. When the protecting group is a benzyl- or p-methoxybenzyl

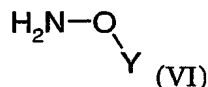
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group, the reaction carried out is a hydrogenolysis in an inert solvent such as an alcohol like methanol or ethanol, in the presence of a noble metal catalyst such as palladium on a suitable carrier such as carbon, barium sulfate, or barium carbonate, at ambient temperature and pressure. When the protecting group is the  
5 tert.butyloxycarbonyl-, trityl-, or a silyl group such as the trimethylsilyl- or dimethyl-tert.butylsilyl-group, the reaction is carried out in the presence of acids at a temperature between -20°C and 60°C, preferably between 0°C and ambient temperature. The acid may be a solution of hydrochloric acid in an inert solvent such as diethyl ether or dioxane, or trifluoro acetic acid in dichloromethane. When  
10 the protecting group is a silyl group such as the trimethylsilyl or dimethyl-tert.butylsilyl group, the reaction can also be carried out in the presence of a fluoride source such as sodium fluoride or tetrabutyl ammonium fluoride in an inert solvent such as dichloromethane. Not necessarily all protecting groups Y are compatible with all groups R1 or R2. In cases where the features of these groups do  
15 not allow the usage of a certain protecting group, other protecting groups Y or other methods of preparation need to be applied.

Compounds of formula IV are obtained from the reaction of compounds of formula V



20 with a compound of the formula VI



wherein Y is a suitable protecting group as described above. This reaction typically involves a two-step one-pot procedure. In the first step, the carboxylate of the formula V becomes activated. This reaction is carried out in an inert solvent or  
25 diluent, for example, in dichloromethane, dioxane, or tetrahydrofuran, in the presence of an activating agent. A suitable reactive derivative of an acid is, for example, an acyl halide, for example an acyl chloride formed by the reaction of the

acid and an inorganic acid chloride, for example thionyl chloride; a mixed anhydride, for example an anhydride formed by the reaction of the acid and a chloroformate such as isobutyl chloroformate; an active ester, for example an ester formed by the reaction of the acid and a phenol such as pentafluorophenol; an active ester formed by the reaction of the acid and N-hydroxybenzotriazole; an acyl azide, for example an azide formed by the reaction of the acid and an azide such as diphenylphosphoryl azide; an acyl cyanide, for example a cyanide formed by the reaction of an acid and a cyanide such as diethylphosphoryl cyanide; or the product of the reaction of the acid and a carbodiimide such as dicyclohexylcarbodiimide, or the product of the reaction of the acid and bis-(2-oxo-3-oxazolidinyl)-phosphorylchloride. The reaction is carried out between -30°C and 60°C, conveniently at or below 0°C. In the second step, compound VI is added to the solution, at the temperature used for the activation, and the temperature is slowly adjusted to ambient temperature. These methods are well known to those skilled in the art. In principle, all methods for the synthesis of amides as used in peptide chemistry as described in e.g. "Methoden der organischen Chemie (Houben-Weyl)" Vol. XV/1 and XV/2 are also applicable.

Compounds of the formula V are prepared from compounds of the formula II by hydrolysis. The conditions under which the hydrolysis is carried out depend on the nature of the group R3. When R3 is a methyl or ethyl group, the reaction is carried out in the presence of a base, for example, lithium hydroxide, sodium hydroxide, or potassium hydroxide in an inert solvent or diluent, for example, in methanol or ethanol. When R3 is the tert.butyl group, the reaction is carried out in the presence of an acid, for example, a solution of hydrochloric acid in an inert solvent such as diethyl ether or dioxane, or trifluoroacetic acid in dichloromethane. When R3 is the benzyl group, the reaction is carried out by hydrogenolysis in the presence of a noble metal catalyst such as palladium or platinum on a suitable carrier, such as carbon. Not necessarily all methods of hydrolysis are compatible with all groups R1 or R2. In cases where the features of these groups do not allow the usage of a certain method of hydrolysis, other methods of preparation need to be applied.

(c) Another preferred method for the preparation of compounds of the formula I is the reaction of a compound of the formula V with hydroxylamine. This reaction typically involves a two-step one-pot procedure. In the first step, the carboxylate of the formula V becomes activated. This reaction is carried out in an inert solvent or diluent, for example, in dichloromethane, dioxane, or tetrahydrofuran, in the

5 presence of an activating agent. A suitable reactive derivative of an acid is, for example, an acyl halide, for example an acyl chloride formed by the reaction of the acid and an inorganic acid chloride, for example thionyl chloride; a mixed anhydride, for example an anhydride formed by the reaction of the acid and a  
10 chloroformate such as isobutyl chloroformate; an active ester, for example an ester formed by the reaction of the acid and a phenol such as pentafluorophenol; an active ester formed by the reaction of the acid and N-hydroxybenzotriazole; an acyl azide, for example an azide formed by the reaction of the acid and an azide such as diphenylphosphoryl azide; an acyl cyanide, for example a cyanide formed by the  
15 reaction of an acid and a cyanide such as diethylphosphoryl cyanide; or the product of the reaction of the acid and a carbodiimide such as dicyclohexylcarbodiimide, or the product of the reaction of the acid and bis-(2-oxo-3-oxazolidinyl)-phosphorylchloride. The reaction is carried out between -30°C and 60°C, conveniently at or below 0°C. In the second step, hydroxylamine is added to the  
20 solution, at the temperature used for the activation, and the temperature is slowly adjusted to ambient temperature. These methods are well known to those skilled in the art. In principle, all methods for the synthesis of amides as used in peptide chemistry as described in e.g. "Methoden der organischen Chemie (Houben-Weyl)" Vol. XV/1 and XV/2 are also applicable.

20 (d) Compounds of formula I can also be prepared with methods of solid phase supported synthesis. Terephthalic acid or 2,5-thiophenedicarboxylic acid is reacted with a hydroxylamine moiety (-O-NH<sub>2</sub>) bound to a resin, e.g. a Wang resin (Wang-O-NH<sub>2</sub> resin was supplied by EMC microcollections, Tübingen) to form a resin-bound hydroxamic acid. The second carbonic acid moiety is reacted with an amine  
25 by standard methods of amide formation as described in e.g. "Methoden der organischen Chemie (Houben-Weyl)" Vol. XV/1 and XV/2. After this, the hydroxamic acid is liberated from the solid support. This can be done for example with TFA. The crude product can be purified by LC-MS, if necessary.

30 The invention will now be illustrated in the following non-limiting examples in which, unless otherwise stated:

(i) evaporations were carried out by rotary evaporation in vacuo and work-up procedures were carried out after removal of residual solids such as drying agents by filtration;

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- (ii) operations were carried out at ambient temperature, that is in the range 18-25°C and under an atmosphere of an inert gas such as argon or nitrogen;
- (iii) column chromatography (by the flash procedure) and high pressure liquid chromatography (HPLC) were performed on Merck Kieselgel silica or Merck Lichroprep RP-18 reversed-phase silica obtained from E. Merck, Darmstadt, Germany;
- (iv) yields are given for illustration only and are not necessarily the maximum attainable;
- (v) melting points were determined using a Mettler SP62 automatic melting point apparatus, an oil-bath apparatus or a Kofler hot plate apparatus.
- (vi) the structures of the end-products of the formula I were confirmed by nuclear (generally proton) magnetic resonance (NMR) and mass spectral techniques (Micromass Platform II machine using APCI or Micromass Platform ZMD using electrospray);
- (vii) intermediates were not generally fully characterized and purity was assessed by thin layer chromatography;
- (viii) the following abbreviations have been used:
- DMF, N,N-dimethylformamide;  
DMSO, dimethylsulphoxide;  
THF, tetrahydrofuran;  
MeOH, methanol;  
HCl, hydrochloric acid;  
NaH, sodium hydride  
CH<sub>2</sub>Cl<sub>2</sub>, dichloromethane;  
H<sub>2</sub>SO<sub>4</sub>, sulphuric acid  
sat., saturated  
sol., solution  
rt, room temperature  
eq, equivalent

**Example 1**

Thiophene-2,5-dicarboxylic acid 2-hydroxyamide 5-[(naphthalen-1-ylmethyl)-amide] (1a)

5 1.9g Thiophene-2,5-dicarboxylic acid monomethyl ester and 1.2mL N-methylmorpholine is dissolved in 20mL of CH<sub>2</sub>Cl<sub>2</sub> at -10°C. To this solution is added 1.5mL isobutyl chloroformate. After 10min of stirring, 1.7mL 1-(aminomethyl)-naphthalene in 5mL of CH<sub>2</sub>Cl<sub>2</sub> is added. The cooling bath is removed and the reaction mixture is allowed to reach rt. After 90min, 10mL of water and 10mL 2N HCl are added. The phases are separated, and the organic phase is washed with water. After evaporation of the solvent there is obtained 4.4g  
10 crude 5-[(naphthalen-1-ylmethyl)-carbamoyl]-thiophene-2-carboxylic acid methyl ester (1b) which is purified by recrystallisation from ethylacetate, petrol ether, yielding 58%, mp 125°C.

15 To a solution of 550mg hydroxylamine hydrochloride in 8mL MeOH is added 2/3 of a solution of 275mg of sodium in 8mL of MeOH. To this, a solution of 1.30g 5-[(naphthalen-1-ylmethyl)-carbamoyl]-thiophene-2-carboxylic acid methyl ester (1b) in 30mL MeOH is added, followed by the remaining sodium methylate solution. After stirring for 4h at rt the solvent is evaporated. 20mL of water are added, , acidified with 4mL 50% acetic acid, and the precipitate is collected by filtration.  
20 After trituration with THF there is obtained 0.76g thiophene-2,5-dicarboxylic acid 2-hydroxyamide 5-[(naphthalen-1-ylmethyl)-amide] (1a) as a white powder, mp 170°C.

**Example 2**

25 Thiophene-2,5-dicarboxylic acid 2-hydroxyamide 5-(4-trifluoromethyl-benzylamide) (2a)

2a is prepared from thiophene-2,5-dicarboxylic acid monomethyl ester in an analogous manner to that described for the preparation of 1a example 1. The last step yields 40% of thiophene-2,5-dicarboxylic acid 2-hydroxyamide 5-(4-trifluoromethyl-benzylamide) (2a), mp. 172-174°C.



**Example 3****N-hydroxy-N'-naphthalen-1-ylmethyl-terephthalamide (3a)**

1eq of Wang-O-NH<sub>2</sub> is shaken with 11eq of terephthalic acid, 5.5eq N,N'-diisopropylcarbodiimide, 5.5eq 1-hydroxybenzotriazole and 25eq diisopropylethylamine in DMF for 4h at 25°C. After that, the resin is washed with DMF (5 times), MeOH (3 times), THF (3 times), CH<sub>2</sub>Cl<sub>2</sub> (3 times) and diethylether (3 times). The resin is then shaken with 5eq pentafluorophenyl trifluoroacetate and 10eq pyridine. After that, the resin is washed with DMF (2 times), followed by CH<sub>2</sub>Cl<sub>2</sub> (2 times), followed by diethylether (2 times). The resin is then shaken with 5eq of naphthalenemethylamine, 10eq of diisopropylethylamine and 1eq of 1-hydroxybenzotriazole. It is then shaken with 5eq pentafluorophenyl trifluoroacetate and 10eq pyridine. After that, the resin is washed with DMF (2 times), followed by CH<sub>2</sub>Cl<sub>2</sub> (2 times). To liberate the product from the solid support, the resin is shaken with 50% TFA in dry CH<sub>2</sub>Cl<sub>2</sub> with 5% triisopropylsilane added at rt for 1h. The liquid phase is filtered, the resin washed with CH<sub>2</sub>Cl<sub>2</sub> (3 times), and the combined filtrates are evaporated. The crude product is dissolved in *tert*-butanol/H<sub>2</sub>O (80:20) and freeze-dried. To neutralize any remaining TFA, 100µL of a 25% NH<sub>4</sub>OH-sol is added and freeze-dried, again. The remaining solid is purified by preparative LC-MS to N-hydroxy-N'-naphthalen-1-ylmethyl-terephthalamide, MS (APCI): 321.1 (M+1)

**Example 4****Thiophene-2,5-dicarboxylic acid 2-(3-chloro-benzylamide) 5-hydroxyamide (4a)**

9.0g Thiophene-2,5-dicarboxylic acid monomethyl ester is refluxed in 30mL of thionylchloride until gas evolution has ceased. The mixture is evaporated and the residue is slowly added to a solution of 10.3g 3-chlorobenzylamine and 20g triethylamine in 180mL CH<sub>2</sub>Cl<sub>2</sub> at 0°C. After 15min the cooling bath is removed and the reaction mixture is allowed to reach rt. After 2h it is quenched with water, the phases are separated, and the aqueous phase is extracted with CH<sub>2</sub>Cl<sub>2</sub>. The combined organic phases are dried with Na<sub>2</sub>SO<sub>4</sub> and evaporated yielding a crude product. This is purified by recrystallisation from diethylether / heptane yielding 13.9g (93%) crude 5-[(3-chlorobenzyl)-carbamoyl]-thiophene-2-carboxylic acid methyl ester (4b), mp 91-93°C. To a solution of 2.9g hydroxylamine hydrochloride in 45mL MeOH is added 25mL of a solution of 1.4g sodium in 40mL of MeOH. To this, a solution of 6.4g ester 4b in 30mL MeOH is added, followed by the remaining

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15mL of the sodium methylate solution. After stirring for 3h at rt the solution is acidified with 1N HCl and some ethylacetate is added. Thiophene-2,5-dicarboxylic acid 2-(3-chloro-benzylamide) 5-hydroxyamide (4a) precipitates as a white solid; 4.7g, 73%, mp. 183°C.

5     Example 5

Thiophene-2,5-dicarboxylic acid 2-(3,5-dimethyl-benzylamide) 5-hydroxyamide (5a)

5a is prepared from thiophene-2,5-dicarboxylic acid monomethyl ester in an analogous manner to that described for the preparation of 4a example 4. MS (APCI): 305.3 (M+1)

10

Example 6

Thiophene-2,5-dicarboxylic acid 2-hexylamide 5-hydroxyamide (6a)

6a is prepared from thiophene-2,5-dicarboxylic acid monomethyl ester in an analogous manner to that described for the preparation of 4a example 4, mp 171-173°C

15

Example 7

Thiophene-2,4-dicarboxylic acid 2-(3,5-dimethyl-benzylamide) 4-hydroxyamide (7a)

0.5g 2-carboxy-thiophen-4-carboxylic acid ethyl ester (Janda, M., et al., Org. Prep. and Proced. Int. 3 (6) (1971) 295-297) and 0.67g N'-(3-dimethylaminopropyl)-N-ethylcarbodiimid x HCl are stirred in 50mL DCM for 15min. Then, 0.338g 3,5-dimethylbenzylamin are added and the mixture is stirred overnight. The solution is extracted with 2N HCl and water, then evaporated. The residue is titrated with isohexan, and the resulting crystals are filtrated and air-dried, yielding 0.58g (73%) crude 5-(3,5-Dimethyl-benzylcarbamoyl)-thiophene-3-carboxylic acid ethyl ester (7b). This ester is converted to title compound by reaction with hydroxylamine hydrochloride in a manner similar to that described for the conversion of 4b into 4a in example 4. After chromatography (silica, ethylacetate), thiophene-2,4-dicarboxylic acid 2-(3,5-dimethyl-benzylamide) 4-hydroxyamide (7a) is obtained as crystals; 44mg, 9%, mp: 181°C (decomp.).

20

25

30

Example 8

Thiophene-2,4-dicarboxylic acid 2-(3-chloro-benzylamide) 4-hydroxyamide (8a)

8a is prepared from 2-carboxy-thiophen-4-carboxylic acid ethyl ester in an analogous manner to that described for the preparation of 7a example 7; 163mg, 34%, mp: 90°C (decomp.).

Example 9

Thiophene-2,4-dicarboxylic acid 4-hydroxyamide 2-(4-trifluoromethyl-benzylamide) (9a)

9a is prepared from 2-carboxy-thiophen-4-carboxylic acid ethyl ester in an analogous manner to that described for the preparation of 7a example 7; 56mg, 10%, mp: 174-177°C.

Example 10

Thiophene-2,4-dicarboxylic acid 2-[(benzo[1,3]dioxol-5-ylmethyl)-amide] 4-hydroxyamide (10a)

10a is prepared from 2-carboxy-thiophen-4-carboxylic acid ethyl ester in an analogous manner to that described for the preparation of 7a example 7; 16mg, 3%, mp: 182°C (decomp.).

Example 11

Thiophene-2,4-dicarboxylic acid 2-hexylamide 4-hydroxyamide (11a)

11a is prepared from 2-carboxy-thiophen-4-carboxylic acid ethyl ester in an analogous manner to that described for the preparation of 7a example 7; 92mg, 20%, mp: 150°C (decomp.).

Example 12

Thiophene-2,4-dicarboxylic acid 4-(3,5-dimethyl-benzylamide) 2-hydroxyamide(12a)

5.0g 2-carboxy-thiophen-4-carboxylic acid ethyl ester (Org. Prep. and Proced. Int. 3 (6) (1971) 295) is dissolved in 50mL THF and 4.5g thionylchloride is added. After refluxing for 4h, the mixture is evaporated. The crude acid chloride is added to a

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5 solution of 3.1g O-benzylhydroxylamine and 3.06g triethylamine in 80mL DCM. After stirring for 4h the solution is washed with 2N HCl and water, dried and evaporated. After titrating the residue with isohexan / diethylether, bright crystals of 5-benzyloxycarbamoyl-thiophene-3-carboxylic acid ethyl ester (12b) are  
10 obtained, which are filtered and air-dried; 3.5g, 46%. 0.46g NaOH are dissolved in 45mL ethanol and 5mL water. The ester 12b is added and the solution refluxed for 2h. After cooling, the ethanol is evaporated and the aqueous phase extracted with diethylether. The aqueous phase is acidified with 2N HCl and the precipitate formed is collected by filtration, yielding 2.8g (88%) 5-benzyloxycarbamoyl-thiophene-3-carboxylic acid (12c) as a solid.

0.4g 5-benzyloxycarbamoyl-thiophene-3-carboxylic acid (12c) is dissolved in 50mL DCM, and 0.387g N-(3-dimethylaminopropyl)-N-ethylcarbodiimid x HCl are added. After stirring for 15min, 0.195g 3,5-dimethylbenzylamine is added, and the mixture is stirred overnight.

15 The solution is extracted with 2N HCl and water, then evaporated. The residue is titrated with ether/isohexan, and the resulting crystals are filtrated and air-dried, yielding 0.44g (77%) of thiophene-2,4-dicarboxylic acid 2-(benzyloxy-amide) 4-(3,5-dimethyl-benzylamide) (12d). This is hydrogenated in a 1:1 mixture of THF and MeOH using Pd/CaSO<sub>4</sub>/C and purified by preparative HPLC/MS yielding 12a:  
20 MS (APCI): 303.1 (M-1).

### Example 13

In an analogous manner to that described in the example 12, the following compounds are prepared:

- 25
1. Thiophene-2,4-dicarboxylic acid 4-(3-chloro-benzylamide) 2-hydroxyamide
  2. Thiophene-2,4-dicarboxylic acid 4-hexylamide 2-hydroxyamide

Example 14

4-[[ (5-Hydroxycarbamoyl-thiophene-2-carbonyl)-amino]-methyl]-benzoic acid methyl ester

5 In an analogous manner to that described in the example 12, but using 2-carboxy-thiophen-5-carboxylic acid methyl ester and methyl 4-(aminomethyl)- benzoate as starting material, 4-[[ (5-Hydroxycarbamoyl-thiophene-2-carbonyl)-amino]-methyl]-benzoic acid methyl ester is prepared, mp.: 156-166°C.

Example 15

10 In an analogous manner to that described in the example 1, and using known methods as described in the literature (e.g. in standard works such as Houben-Weyl, "Methoden der Organischen Chemie, Georg Thieme Verlag", Stuttgart; Organic Reactions, John Wiley & Sons, Inc., New York) the following compounds are prepared and characterized with MS (APCI):

- 15 1. 5-(4-benzhydryl-piperazine-1-carbonyl)-thiophene-2-carboxylic acid hydroxyamide
2. thiophene-2,5-dicarboxylic acid 2-benzylamide 5-hydroxyamide
3. thiophene-2,5-dicarboxylic acid 2-hydroxyamide 5-[(3-methyl-butyl)-amide]
4. thiophene-2,5-dicarboxylic acid 2-hydroxyamide 5-(phenethyl-amide)
- 20 5. thiophene-2,5-dicarboxylic acid 2-hydroxyamide 5-[[2-(4-methoxy-phenyl)-ethyl]-amide]
6. thiophene-2,5-dicarboxylic acid 2-(4-fluoro-benzylamide) 5-hydroxyamide
7. thiophene-2,5-dicarboxylic acid 2-hydroxyamide 5-[(1,2,3,4-tetrahydro-naphthalen-1-yl)-amide]
- 25 8. thiophene-2,5-dicarboxylic acid 2-(2-ethoxy-benzylamide) 5-hydroxyamide
9. thiophene-2,5-dicarboxylic acid 2-(2,4-difluoro-benzylamide) 5-hydroxyamide
10. thiophene-2,5-dicarboxylic acid 2-hydroxyamide 5-indan-1-ylamide
11. thiophene-2,5-dicarboxylic acid 2-[(benzo[1,3]dioxol-5-ylmethyl)-amide] 5-hydroxyamide
- 30 12. 5-(4-phenyl-piperazine-1-carbonyl)-thiophene-2-carboxylic acid hydroxyamide
13. thiophene-2,5-dicarboxylic acid 2-hydroxyamide 5-[(3-isopropoxy-propyl)-amide]
14. 5-(4-acetyl-piperazine-1-carbonyl)-thiophene-2-carboxylic acid hydroxyamide

15. thiophene-2,5-dicarboxylic acid 2-dibutylamide 5-hydroxyamide
16. 5-(4-benzyl-piperidine-1-carbonyl)-thiophene-2-carboxylic acid hydroxyamide
17. thiophene-2,5-dicarboxylic acid 2-hydroxyamide 5-[(pyridin-3-ylmethyl)-amide]
- 5 18. thiophene-2,5-dicarboxylic acid 2-cyclohexylamide 5-hydroxyamide
19. thiophene-2,5-dicarboxylic acid 2-cyclopropylamide 5-hydroxyamide
20. thiophene-2,5-dicarboxylic acid 2-hydroxyamide 5-[[2-(1-methyl-pyrrolidin-2-yl)-ethyl]-amide]
21. thiophene-2,5-dicarboxylic acid 2-hydroxyamide 5-(2-methoxy-benzylamide)
- 10 22. thiophene-2,5-dicarboxylic acid 2-[(2-cyclohex-1-enyl-ethyl)-amide] 5-hydroxyamide
23. thiophene-2,5-dicarboxylic acid 2-hydroxyamide 5-[(2-morpholin-4-yl-ethyl)-amide]
24. thiophene-2,5-dicarboxylic acid 2-hydroxyamide 5-[(2-methylsulfanyl-ethyl)-amide]
- 15 25. thiophene-2,5-dicarboxylic acid 2-hydroxyamide 5-[(tetrahydro-furan-2-ylmethyl)-amide]
26. thiophene-2,5-dicarboxylic acid 2-hydroxyamide 5-phenylamide
27. 5-(morpholine-4-carbonyl)-thiophene-2-carboxylic acid hydroxyamide
- 20 28. thiophene-2,5-dicarboxylic acid 2-hydroxyamide 5-[(4-methoxy-phenyl)-amide]
29. 5-(pyrrolidine-1-carbonyl)-thiophene-2-carboxylic acid hydroxyamide
30. thiophene-2,5-dicarboxylic acid 2-[(4-benzyloxy-phenyl)-amide] 5-hydroxyamide
- 25 31. thiophene-2,5-dicarboxylic acid 2-[(4-chloro-phenyl)-amide] 5-hydroxyamide
32. thiophene-2,5-dicarboxylic acid 2-hydroxyamide 5-[(4-iodo-phenyl)-amide]
33. thiophene-2,5-dicarboxylic acid 2-[(3-ethyl-phenyl)-amide] 5-hydroxyamide
34. thiophene-2,5-dicarboxylic acid 2-[(4-ethyl-phenyl)-amide] 5-hydroxyamide
35. thiophene-2,5-dicarboxylic acid 2-[(3-chloro-phenyl)-amide] 5-hydroxyamide
- 30 36. thiophene-2,5-dicarboxylic acid 2-hydroxyamide 5-[(3-iodo-phenyl)-amide]
37. 5-(1,4-dioxo-8-aza-spiro[4.5]decane-8-carbonyl)-thiophene-2-carboxylic acid hydroxyamide
38. thiophene-2,5-dicarboxylic acid 2-hydroxyamide 5-[(3-morpholin-4-yl-propyl)-amide]
- 35 39. thiophene-2,5-dicarboxylic acid 2-hydroxyamide 5-pentylamide
40. thiophene-2,5-dicarboxylic acid 2-[(2-diethylamino-ethyl)-amide] 5-hydroxyamide

41. thiophene-2,5-dicarboxylic acid 2-heptylamide 5-hydroxyamide
42. thiophene-2,5-dicarboxylic acid 2-hydroxyamide 5-(isobutyl-amide)
43. thiophene-2,5-dicarboxylic acid 2-hydroxyamide 5-nonylamide
44. thiophene-2,5-dicarboxylic acid 2-hydroxyamide 5-[(1-phenyl-ethyl)-amide]
- 5 45. thiophene-2,5-dicarboxylic acid 2-[2-(4-fluoro-phenyl)-ethyl]-amide  
5-hydroxyamide
46. thiophene-2,5-dicarboxylic acid 2-hydroxyamide 5-[2-(5-nitro-pyridin-2-ylamino)-ethyl]-amide
47. thiophene-2,5-dicarboxylic acid 2-hydroxyamide 5-(3-methyl-benzylamide)
- 10 48. thiophene-2,5-dicarboxylic acid 2-hydroxyamide 5-[(2-p-tolyl-ethyl)-amide]
49. thiophene-2,5-dicarboxylic acid 2-hydroxyamide 5-[3-(2-oxo-pyrrolidin-1-yl)-propyl]-amide
50. thiophene-2,5-dicarboxylic acid 2-hydroxyamide 5-[(2-piperidin-1-yl-ethyl)-amide]
- 15 51. thiophene-2,5-dicarboxylic acid 2-cyclobutylamide 5-hydroxyamide
52. thiophene-2,5-dicarboxylic acid 2-(2-fluoro-benzylamide) 5-hydroxyamide
53. thiophene-2,5-dicarboxylic acid 2-hydroxyamide 5-[(2-phenyl-propyl)-amide]
54. thiophene-2,5-dicarboxylic acid 2-(2,3-dimethoxy-benzylamide)  
5-hydroxyamide
- 20 55. thiophene-2,5-dicarboxylic acid 2-[(1-benzyl-piperidin-4-yl)-amide]  
5-hydroxyamide
56. 4-[(5-hydroxycarbamoyl-thiophene-2-carbonyl)-amino]-piperidine-1-carboxylic acid ethyl ester
57. thiophene-2,5-dicarboxylic acid 2-[(3-dimethylamino-2,2-dimethyl-propyl)-amide] 5-hydroxyamide
- 25 58. thiophene-2,5-dicarboxylic acid 2-[(3-ethoxy-propyl)-amide] 5-hydroxyamide
59. thiophene-2,5-dicarboxylic acid 2-[(3-dimethylamino-propyl)-amide]  
5-hydroxyamide
60. thiophene-2,5-dicarboxylic acid 2-[2-(2-chloro-phenyl)-ethyl]-amide  
5-hydroxyamide
- 30 61. thiophene-2,5-dicarboxylic acid 2-hydroxyamide 5-(2-trifluoromethyl-benzylamide)
62. thiophene-2,5-dicarboxylic acid 2-hydroxyamide 5-(3-trifluoromethyl-benzylamide)
- 35 63. thiophene-2,5-dicarboxylic acid 2-(2,5-difluoro-benzylamide) 5-hydroxyamide
64. thiophene-2,5-dicarboxylic acid 2-(2,6-difluoro-benzylamide) 5-hydroxyamide
65. thiophene-2,5-dicarboxylic acid 2-(3,4-difluoro-benzylamide) 5-hydroxyamide

66. thiophene-2,5-dicarboxylic acid 2-hydroxyamide 5-[(3-imidazol-1-yl-propyl)-amide]
67. thiophene-2,5-dicarboxylic acid 2-[(1-cyclohexyl-ethyl)-amide] 5-hydroxyamide
- 5 68. thiophene-2,5-dicarboxylic acid 2-[2-(3-chloro-phenyl)-ethyl]-amide 5-hydroxyamide
69. thiophene-2,5-dicarboxylic acid 2-[2-(3-fluoro-phenyl)-ethyl]-amide 5-hydroxyamide
70. thiophene-2,5-dicarboxylic acid 2-[2-(2,4-dichloro-phenyl)-ethyl]-amide 5-hydroxyamide
- 10 71. thiophene-2,5-dicarboxylic acid 2-cyclopropylmethyl-amide 5-hydroxyamide
72. thiophene-2,5-dicarboxylic acid 2-[2-(2-fluoro-phenyl)-ethyl]-amide 5-hydroxyamide
73. thiophene-2,5-dicarboxylic acid 2-[(4-diethylamino-1-methyl-butyl)-amide] 5-hydroxyamide
- 15 74. thiophene-2,5-dicarboxylic acid 2-hydroxyamide 5-[(2-pyridin-2-yl-ethyl)-amide]
75. thiophene-2,5-dicarboxylic acid 2-hydroxyamide 5-[(2-pyrrolidin-1-yl-ethyl)-amide]
- 20 76. thiophene-2,5-dicarboxylic acid 2-hydroxyamide 5-[(1-methyl-hexyl)-amide]
77. thiophene-2,5-dicarboxylic acid 2-cycloheptylamide 5-hydroxyamide
78. thiophene-2,5-dicarboxylic acid 2-cyclopentylamide 5-hydroxyamide
79. thiophene-2,5-dicarboxylic acid 2-(2,4-dichloro-benzylamide) 5-hydroxyamide
80. thiophene-2,5-dicarboxylic acid 2-[(3-diethylamino-propyl)-amide] 5-hydroxyamide
- 25 81. thiophene-2,5-dicarboxylic acid 2-[(1,5-dimethyl-hexyl)-amide] 5-hydroxyamide
82. thiophene-2,5-dicarboxylic acid 2-[(2,2-diphenyl-ethyl)-amide] 5-hydroxyamide
- 30 83. 3-[(5-hydroxycarbamoyl-thiophene-2-carbonyl)-amino]-butyric acid ethyl ester
84. thiophene-2,5-dicarboxylic acid 2-[(2-ethyl-hexyl)-amide] 5-hydroxyamide
85. thiophene-2,5-dicarboxylic acid 2-hydroxyamide 5-(4-methoxy-benzylamide)
86. thiophene-2,5-dicarboxylic acid 2-hydroxyamide 5-(4-methyl-benzylamide)
- 35 87. thiophene-2,5-dicarboxylic acid 2-hydroxyamide 5-[(3-phenyl-propyl)-amide]
88. thiophene-2,5-dicarboxylic acid 2-[(2-diisopropylamino-ethyl)-amide] 5-hydroxyamide



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89. thiophene-2,5-dicarboxylic acid 2-hydroxyamide 5-[2-(4-nitro-phenyl)-ethyl]-amide
90. thiophene-2,5-dicarboxylic acid 2-[(3,3-diphenyl-propyl)-amide] 5-hydroxyamide
- 5 91. thiophene-2,5-dicarboxylic acid 2-(2-amino-benzylamide) 5-hydroxyamide
92. Thiophene-2,5-dicarboxylic acid 2-(4-bromo-benzylamide) 5-hydroxyamide
93. Thiophene-2,5-dicarboxylic acid 2-(3,5-bis-trifluoromethyl-benzylamide) 5-hydroxyamide
94. Thiophene-2,5-dicarboxylic acid 2-(3-bromo-benzylamide) 5-hydroxyamide
- 10 95. Thiophene-2,5-dicarboxylic acid 2-(3-fluoro-benzylamide) 5-hydroxyamide
96. Thiophene-2,5-dicarboxylic acid 2-hydroxyamide 5-(3-methoxy-benzylamide)
97. Thiophene-2,5-dicarboxylic acid 2-(2-chloro-6-fluoro-benzylamide) 5-hydroxyamide
98. Thiophene-2,5-dicarboxylic acid 2-(4-tert-butyl-benzylamide) 5-hydroxyamide
- 15 99. Thiophene-2,5-dicarboxylic acid 2-hydroxyamide 5-{[2-(4-sulfamoyl-phenyl)-ethyl]-amide}
100. Thiophene-2,5-dicarboxylic acid 2-[(2-benzylsulfanyl-ethyl)-amide] 5-hydroxyamide
101. Thiophene-2,5-dicarboxylic acid 2-hydroxyamide 5-{[2-(4-hydroxy-phenyl)-ethyl]-amide}
- 20 102. Thiophene-2,5-dicarboxylic acid 2-{[2-(4-chloro-phenyl)-ethyl]-amide} 5-hydroxyamide
103. Thiophene-2,5-dicarboxylic acid 2-{[2-(3,4-dimethoxy-phenyl)-ethyl]-amide} 5-hydroxyamide
- 25 104. Thiophene-2,5-dicarboxylic acid 2-hydroxyamide 5-[(2-phenoxy-ethyl)-amide]
105. Thiophene-2,5-dicarboxylic acid 2-hydroxyamide 5-[(4-phenyl-butyl)-amide]
106. Thiophene-2,5-dicarboxylic acid 2-[(3,4-dimethyl-phenyl)-amide] 5-hydroxyamide
- 30 107. 5-(4-Pyrimidin-2-yl-piperazine-1-carbonyl)-thiophene-2-carboxylic acid hydroxyamide
108. Thiophene-2,5-dicarboxylic acid 2-[(3,4-dimethoxy-phenyl)-amide] 5-hydroxyamide
- 35 109. Thiophene-2,5-dicarboxylic acid 2-[(4-tert-butyl-phenyl)-amide] 5-hydroxyamide

110. Thiophene-2,5-dicarboxylic acid 2-hydroxyamide 5-[(4-methoxy-2-methyl-phenyl)-amide]  
111. Thiophene-2,5-dicarboxylic acid 2-[(4-dimethylamino-phenyl)-amide]  
5-hydroxyamide  
5 112. Thiophene-2,5-dicarboxylic acid 2-hydroxyamide 5-[(4-phenoxy-phenyl)-amide]  
113. Thiophene-2,5-dicarboxylic acid 2-hydroxyamide 5-p-tolylamide  
114. Thiophene-2,5-dicarboxylic acid 2-hydroxyamide 5-[(4-piperidin-1-yl-phenyl)-amide]  
10 115. 1-(5-Hydroxycarbamoyl-thiophene-2-carbonyl)-piperidine-4-carboxylic acid methyl ester  
116. Thiophene-2,5-dicarboxylic acid 2-hydroxyamide 5-[methyl-(1-methyl-piperidin-4-yl)-amide]  
117. Thiophene-2,5-dicarboxylic acid 2-hydroxyamide 5-{methyl-[2-(4-nitro-phenyl)-ethyl]-amide}  
15 118. Thiophene-2,5-dicarboxylic acid 2-(butyl-methyl-amide) 5-hydroxyamide  
119. Thiophene-2,5-dicarboxylic acid 2-diethylamide 5-hydroxyamide  
120. Thiophene-2,5-dicarboxylic acid 2-[(4-cyclohexyl-phenyl)-amide] 5-hydroxyamide  
20 121. Thiophene-2,5-dicarboxylic acid 2-hydroxyamide 5-[methyl-(2-methylamino-ethyl)-amide]  
122. Thiophene-2,5-dicarboxylic acid 2-[ethyl-(3-ethylamino-propyl)-amide] 5-hydroxyamide  
123. 5-[4-(2-Morpholin-4-yl-2-oxo-ethyl)-piperazine-1-carbonyl]-thiophene-2-carboxylic acid hydroxyamide  
25 124. 5-(4-Dimethylcarbamoymethyl-piperazine-1-carbonyl)-thiophene-2-carboxylic acid hydroxyamide  
125. 5-[4-(2-Oxo-2-piperidin-1-yl-ethyl)-piperazine-1-carbonyl]-thiophene-2-carboxylic acid hydroxyamide  
30 126. Thiophene-2,5-dicarboxylic acid 2-hydroxyamide 5-(3-trifluoromethoxy-benzylamide)  
127. Thiophene-2,5-dicarboxylic acid 2-hydroxyamide 5-(3-phenoxy-benzylamide)  
128. Thiophene-2,5-dicarboxylic acid 2-hydroxyamide 5-[(1-methyl-3-phenyl-propyl)-amide]  
35 129. Thiophene-2,5-dicarboxylic acid 2-hydroxyamide 5-[(3-methoxy-propyl)-amide]

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130. Thiophene-2,5-dicarboxylic acid 2-(4-chloro-benzylamide)  
5-hydroxyamide
131. Thiophene-2,5-dicarboxylic acid 2-[(2-acetyl-amino-ethyl)-amide]  
5-hydroxyamide
- 5 132. Thiophene-2,5-dicarboxylic acid 2-hydroxyamide 5-[(1-methyl-heptyl)-amide]
133. Thiophene-2,5-dicarboxylic acid 2-hydroxyamide 5-[(1-methyl-butyl)-amide]
134. Thiophene-2,5-dicarboxylic acid 2-allylamide 5-hydroxyamide
- 10 135. Thiophene-2,5-dicarboxylic acid 2-[(1,3-dimethyl-butyl)-amide]  
5-hydroxyamide
136. Thiophene-2,5-dicarboxylic acid 2-hydroxyamide 5-propylamide
137. Thiophene-2,5-dicarboxylic acid 2-sec-butylamide 5-hydroxyamide
138. Thiophene-2,5-dicarboxylic acid 2-butylamide 5-hydroxyamide
- 15 139. Thiophene-2,5-dicarboxylic acid 2-(3,4-dichloro-benzylamide)  
5-hydroxyamide
140. Thiophene-2,5-dicarboxylic acid 2-(2,3-dichloro-benzylamide)  
5-hydroxyamide
141. thiophene-2,5-dicarboxylic acid 2-(2,3-difluoro-benzylamide)  
20 5-hydroxyamide
142. thiophene-2,5-dicarboxylic acid 2-(2-chloro-benzylamide) 5-hydroxyamide
143. thiophene-2,5-dicarboxylic acid 2-(3,4-dimethoxy-benzylamide)  
5-hydroxyamide
144. thiophene-2,5-dicarboxylic acid 2-(3,5-difluoro-benzylamide)  
25 5-hydroxyamide
145. thiophene-2,5-dicarboxylic acid 2-[(2-amino-phenyl)-amide]  
5-hydroxyamide
146. thiophene-2,5-dicarboxylic acid 2-[4-(2-amino-phenylcarbonyl)-  
benzylamide] 5-(benzyloxy-amide)

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147. thiophene-2,5-dicarboxylic acid 2-hydroxyamide 5-[methyl-(4-trifluoromethyl-benzyl)-amide

Example 16

- 5 In an analogous manner to that described in the example 3, and using known methods as described in the literature (e.g. in standard works such as Houben-Weyl, "Methoden der Organischen Chemie, Georg Thieme Verlag", Stuttgart; Organic Reactions, John Wiley & Sons, Inc., New York) the following compounds are prepared and characterized with MS (APCI):
- 10 148. 4-(4-benzhydryl-piperazine-1-carbonyl)-N-hydroxy-benzamide  
149. N-hydroxy-N'-pyridin-3-ylmethyl-terephthalamide  
150. N-benzyl-N'-hydroxy-terephthalamide  
151. N-cyclohexyl-N'-hydroxy-terephthalamide  
152. N-cyclopropyl-N'-hydroxy-terephthalamide  
15 153. N-hexyl-N'-hydroxy-terephthalamide  
154. N-hydroxy-N'-(3-methyl-butyl)-terephthalamide  
155. N-hydroxy-N'-phenethyl-terephthalamide  
156. N-hydroxy-N'-[2-(4-methoxy-phenyl)-ethyl]-terephthalamide  
157. N-(3-chloro-benzyl)-N'-hydroxy-terephthalamide  
20 158. N-hydroxy-N'-(2-methoxy-benzyl)-terephthalamide  
159. N-(4-fluoro-benzyl)-N'-hydroxy-terephthalamide  
160. N-hydroxy-N'-(1,2,3,4-tetrahydro-naphthalen-1-yl)-terephthalamide  
161. N-hydroxy-N'-(4-trifluoromethyl-benzyl)-terephthalamide  
162. N-(2,4-difluoro-benzyl)-N'-hydroxy-terephthalamide  
25 163. N-hydroxy-N'-indan-1-yl-terephthalamide  
164. N-benzo[1,3]dioxol-5-ylmethyl-N'-hydroxy-terephthalamide  
165. N-hydroxy-4-(4-phenyl-piperazine-1-carbonyl)-benzamide  
166. N-(3,5-dimethyl-benzyl)-N'-hydroxy-terephthalamide  
167. N-hydroxy-N'-(3-isopropoxy-propyl)-terephthalamide  
30 168. 4-(4-acetyl-piperazine-1-carbonyl)-N-hydroxy-benzamide  
169. N,N-dibutyl-N'-hydroxy-terephthalamide  
170. 4-(4-benzyl-piperidine-1-carbonyl)-N-hydroxy-benzamide  
171. N-hydroxy-N'-[2-(1-methyl-pyrrolidin-2-yl)-ethyl]-terephthalamide  
172. N-(2-ethoxy-benzyl)-N'-hydroxy-terephthalamide  
35 173. N-(2-cyclohex-1-enyl-ethyl)-N'-hydroxy-terephthalamide

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- 174. N-hydroxy-N'-(2-morpholin-4-yl-ethyl)-terephthalamide
- 175. N-hydroxy-N'-(2-methylsulfanyl-ethyl)-terephthalamide
- 176. N-hydroxy-N'-(tetrahydro-furan-2-ylmethyl)-terephthalamide

5     Example 17

Evaluation of effects on a human colon carcinoma cell line of the compounds of the invention

MTT is widely used for the quantitative determination of cytotoxic effects or in vitro chemosensitivity of tumor cells. The assay is based on the cleavage of the yellow tetrazolium salt MTT to purple formazan crystals by metabolic active cells. For details, see Rubinstein, L.V., et al., J. Natl. Cancer Inst. 82 (1990) 1113-1118.

The following procedure was performed: HT-29 cells (human colon carcinoma cell line) were cultivated in RPMI 1640, 2.5 % FCS, 2 mM Glutamine, 100 u/ml Penicillin, 100 ug/ml Streptomycin. For the assay the cells were seeded in 384 well plates, 900 cells per well, in the same medium. The next day compounds (dissolved 10 mM in DMSO) were added in various concentrations ranging from 30 uM to 1.5 nM. After 5 days the MTT assay was done mainly according to the instructions of the manufacturer (Cell proliferation kit I, MTT, from Roche Molecular Biochemicals). In brief: MTT labeling reagent was added to a final concentration of 0.5 mg/ml, added and incubated for 4 hrs at 37 C, 5% CO<sub>2</sub>. During this incubation time purple formazan crystals are formed. After addition of the solubilization solution (20% SDS in 0.02 M HCl) the plates were incubated overnight at 37 C, 5% CO<sub>2</sub>. After careful mixing plates were measured in Victor 2 (scanning multiwell spectrophotometer, Wallac) at 550 nm.

A decrease in number of living cells results in a decrease in the total metabolic activity in the sample. The decrease directly correlates to the amount of purple colour resulting from the solubilization of the purple formazan crystals. Determination of IC<sub>50</sub> was done using XL-fit.

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Table 1

Compounds according to this invention	IC50 HT29 384 [ $\mu$ M]
Example 15, No. 128	0.02
Example 15, No. 81	0.03
Example 15, No. 104	0.04
Example 5	0.05
Example 15, No. 93	0.05
Example 15, No. 94	0.07
Example 15, No. 98	0.07
Example 2	0.11
Example 4	0.14
Example 15, No. 90	0.14
Example 15, No. 139	0.17

Example 185 **Tablet formulation**

Item	Ingredients	mg/Tablet	
1	Compound 2a	25	100
2	Anhydrous Lactose	73	35
3	Croscarmellose	6	8
	Sodium		
4	Povidone K30	5	6
5	Magnesium Stearate	1	1
	Total Weight	110	150

Compound 2a is described in Example 2.

**Procedure:**

10

1. Mix Items 1, 2 and 3 in a suitable mixer for 15 minutes.
2. Granulate the powder mix from Step 1 with 20% Povidone K30 Solution (Item 4).

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3. Dry the granulation from Step 2 at 50° C.
4. Pass the granulation from Step 3 through a suitable milling equipment.
5. Add the Item 5 to the milled granulation Step 4 and mix for 3 minutes.
6. Compress the granulation from Step 5 on a suitable press.

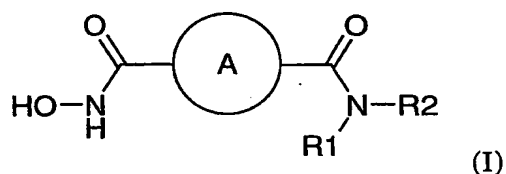
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List of References

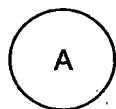
- Cancer: Principles & Practice of Oncology, Vincent T. DeVita, Jr., Samuel Hellmann, Steven A. Rosenberg; 5th Ed., Lippincott-Raven Publishers 1997
- 10 Houben-Weyl, "Methoden der Organischen Chemie, Georg Thieme Verlag", Stuttgart; Organic Reactions, John Wiley & Sons, Inc., New York  
Houben-Weyl, Methoden der organischen Chemie, Vol. XV/1 and XV/2  
Koyama, Y., et al., Blood 96 (2000) 1490-1495  
Marks, P.M., et al., J. Natl. Cancer Inst. 92 (2000) 1210-1216
- 15 Janda, M., et al., Org. Prep. and Proced. Int. 3 (6) (1971) 295-297  
Rubinstein, L.V., et al., J. Natl. Cancer Inst. 82 (1990) 1113-1118  
US 2,680,731  
US 5,369,108  
WO 98/55449
- 20 Holba, V., et al., Z. Phys. Chem.(Leipzig) 262 (3) (1981) 445-448

Patent Claims

## 1. Compounds of formula I



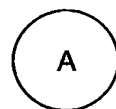
wherein



denotes a phenyl ring which may be unsubstituted or substituted by 1, 2 or 3 substituents independently selected from a halogen atom, an (1-4C)alkyl-, trifluoromethyl-, hydroxy-, (1-4C)alkoxy-, nitro-, amino-, (1-4C)alkylamino-, di[(1-4C)alkyl]-amino-, (1-4C)alkanoylamino, a (1-3C)alkylenedioxy-group or an acyl group,

10

or



denotes or a thiophene ring which may be unsubstituted or substituted by 1 or 2 substituents independently selected from a halogen atom, an (1-4C)alkyl-, trifluoromethyl-, hydroxy-, (1-4C)alkoxy-, nitro-, amino-, (1-4C)alkylamino-, di[(1-4C)alkyl]-amino- or a (1-4C)alkanoylamino, a (1-3C)alkylenedioxy-group or an acyl group,

15

and

R1 and R2 are the same or different from each other and are



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a hydrogen atom;  
a branched or unbranched (1-14C)alkyl group which  
may be unsubstituted or substituted with 1 or several substituents  
independently selected from a halogen atom, hydroxy-, nitro-, amino group  
or by a carbocyclic group or by a heterocyclic group,

and wherein at a chain length of larger than 2 atoms one or several non  
adjacent atoms may be replaced by oxygen, nitrogen or sulfur atoms,

and wherein 2 atoms may be bound together by a double or triple bond;

a carbocyclic group;

or a heterocyclic group;

or R1 and R2 together with the nitrogen atom form a 3-6 membered ring  
which may contain additional heteroatoms independently selected from  
nitrogen, oxygen and sulfur, and which may be annulated by a carbocyclic  
group or by a heterocyclic group and which may be unsubstituted or  
substituted by 1, 2, or 3 substituents independently selected from a halogen  
atom, an (1-4C)alkyl-, trifluoromethyl-, hydroxy-, (1-4C)alkoxy-, aryl-,  
hetaryl-, arylalkyl, arylalkyloxy-, aryloxy, (1-3C)alkylenedioxy-, nitro-,  
amino-, (1-4C)alkylamino-, di[(1-4C)alkyl]amino-, (1-4C)alkanoylamino- or  
an acyl-group;

their enantiomers, diastereoisomers, racemates and physiologically acceptable  
salts thereof.

2. Compounds of formula I according to claim 1 wherein

A

is thiophene, and R<sub>1</sub> is hydrogen and R<sub>2</sub> has the above given meaning.

3. Compounds of formula I according to claims 1 or 2 wherein R<sub>2</sub> is benzyl or  
substituted benzyl.

4. Compounds of formula I according to claim 1 wherein

A

is thiophene and R<sub>1</sub> and R<sub>2</sub> together with the nitrogen atom from a piperazin or piperidine ring which may be substituted by acetyl, benzhydryl or phenyl whereby the phenyl groups can be substituted.

5. Compounds of formula I according to claim 1 selected from the group consisting of

Thiophene-2,5-dicarboxylic acid 2-hydroxyamide 5-[(naphthalen-1-ylmethyl)-amide]

Thiophene-2,5-dicarboxylic acid 2-hydroxyamide 5-(4-trifluoromethyl-benzylamide)

N-hydroxy-N'-naphthalen-1-ylmethyl-terephthalamide

Thiophene-2,5-dicarboxylic acid 2-(3-chloro-benzylamide) 5-hydroxyamide

Thiophene-2,5-dicarboxylic acid 2-(3,5-dimethyl-benzylamide) 5-hydroxyamide

Thiophene-2,5-dicarboxylic acid 2-hexylamide 5-hydroxyamide

Thiophene-2,5-dicarboxylic acid 2-[(1,5-dimethyl-hexyl)-amide] 5-hydroxyamide

Thiophene-2,5-dicarboxylic acid 2-hydroxyamide 5-[(2-phenoxy-ethyl)-amide]

Thiophene-2,5-dicarboxylic acid 2-(3,5-dimethyl-benzylamide) 5-hydroxyamide

Thiophene-2,5-dicarboxylic acid 2-(3,5-bis-trifluoromethyl-benzylamide) 5-hydroxyamide

Thiophene-2,5-dicarboxylic acid 2-(3-bromo-benzylamide) 5-hydroxyamide

Thiophene-2,5-dicarboxylic acid 2-(4-tert-butyl-benzylamide) 5-hydroxyamide

Thiophene-2,5-dicarboxylic acid 2-hydroxyamide 5-(4-trifluoromethyl-benzylamide)

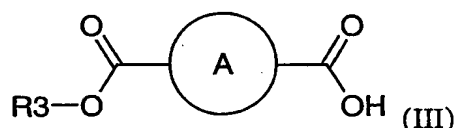
Thiophene-2,5-dicarboxylic acid 2-(3-chloro-benzylamide) 5-hydroxyamide

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	Thiophene-2,5-dicarboxylic acid	2-[(3,3-diphenyl-propyl)-amide]
	5-hydroxyamide	
	Thiophene-2,5-dicarboxylic acid	2-(3,4-dichloro-benzylamide)
	5-hydroxyamide	
5	Thiophene-2,5-dicarboxylic acid	2-hydroxyamide 5-[(1-phenyl-ethyl)-amide]
	Thiophene-2,5-dicarboxylic acid	2-hydroxyamide 5-(3-trifluoromethyl-benzylamide)
	Thiophene-2,5-dicarboxylic acid	2-hydroxyamide 5-[(1-methyl-hexyl)-amide]
10	Thiophene-2,5-dicarboxylic acid	2-heptylamide 5-hydroxyamide
	Thiophene-2,5-dicarboxylic acid	2-hydroxyamide 5-[(4-phenyl-butyl)-amide]
	Thiophene-2,5-dicarboxylic acid	2-benzylamide 5-hydroxyamide
15	Thiophene-2,5-dicarboxylic acid	2-hexylamide 5-hydroxyamide
	Thiophene-2,5-dicarboxylic acid	2-(3-fluoro-benzylamide) 5-hydroxyamide
	Thiophene-2,5-dicarboxylic acid	2-(2,4-difluoro-benzylamide) 5-hydroxyamide
	Thiophene-2,5-dicarboxylic acid	2-[(2-benzylsulfanyl-ethyl)-amide]
20	5-hydroxyamide	
	Thiophene-2,5-dicarboxylic acid	2-(4-bromo-benzylamide) 5-hydroxyamide
	Thiophene-2,5-dicarboxylic acid	2-hydroxyamide 5-[[2-(4-hydroxy-phenyl)-ethyl]-amide]
	Thiophene-2,5-dicarboxylic acid	2-hydroxyamide 5-(4-methoxy-benzylamide)
25	Thiophene-2,5-dicarboxylic acid	2-(2,3-dichloro-benzylamide) 5-hydroxyamide
	Thiophene-2,5-dicarboxylic acid	2-hydroxyamide 5-[(3-phenyl-propyl)-amide]
30	Thiophene-2,5-dicarboxylic acid	2-(2,5-difluoro-benzylamide) 5-hydroxyamide
	Thiophene-2,5-dicarboxylic acid	2-(2-fluoro-benzylamide) 5-hydroxyamide
	Thiophene-2,5-dicarboxylic acid	2-hydroxyamide 5-[(naphthalen-1-ylmethyl)-amide]
35	Thiophene-2,5-dicarboxylic acid	2-hydroxyamide 5-(3-methyl-benzylamide)
	Thiophene-2,5-dicarboxylic acid	2-(2,6-difluoro-benzylamide) 5-hydroxyamide.

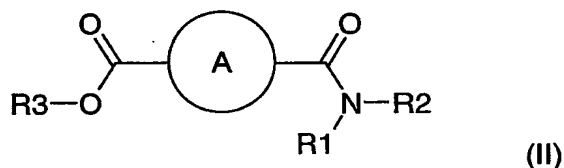
- 35 -

6. Process of manufacturing compounds according to claims 1 to 5 by reacting a compound of formula III



- 5 wherein A has the meaning defined hereinbefore and R<sub>3</sub> is (1-4C) alkyl group

with an amine of the formula HNR<sub>1</sub>R<sub>2</sub> in the presence of an activating agent, wherein R<sub>1</sub> and R<sub>2</sub> have the meaning defined hereinbefore to give a compound of formula II



- 10 which is reacted with hydroxylamine in the presence of a suitable base,
- whereafter the obtained compounds of formula I are converted in its enantiomers, diastereoisomers, racemates or physiologically acceptable salts.
7. Medicaments containing as active ingredients a compound of formula I according to claims 1 to 5 in admixture with pharmaceutically acceptable excipients or diluents.
- 15 8. Use of a compound according to claims 1 to 5 for the preparation of a medicament having histone deacetylase (HDAC) inhibitor activity.
9. Use of a compound according to claim 8 as an inhibitor of cell proliferation.

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(71) Applicant: F. HOFFMAN-LA ROCHE AG [CH/CH];  
124 Grenzacherstrasse, CH-4070 Basle (CH).

(72) Inventors: LESER-REIFF, Ulrike; Weidenweg 6, 82377  
Penzberg (DE). SATTELKAU, Tim; Renzstrasse 1, 68161  
Mannheim (DE). ZIMMERMANN, Gerd; Rheinstrasse  
9A, 76351 Linkenheim (DE).

(74) Agent: SCHREINER, Siegfried; Roche Diagnostics  
GmbH, Patent Department (TR-E), P.O. Box 11 52, 82372  
Penzberg (DE).

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(BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR,  
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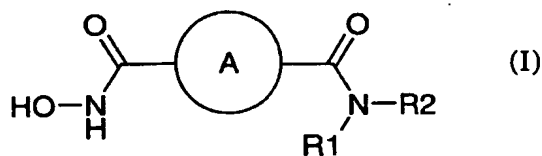
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For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: AROMATIC HYDROXAMIC ACID DERIVATIVES USEFUL AS HDAC INHIBITORS



(57) Abstract: Compounds of formula (I) wherein A, R<sub>1</sub> and R<sub>2</sub> have the meanings defined in the specification, process of manufacturing these compounds and medicaments with HDAC inhibitor activity containing such a compound.

WO 03/011851 A3

## INTERNATIONAL SEARCH REPORT

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PCT/EP 02/06488

## A. CLASSIFICATION OF SUBJECT MATTER

IPC 7 C07D333/38 A61K31/00 C07C259/10 C07D409/12 C07D213/40  
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According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 C07D A61K C07C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 95 31977 A (SLOAN KETTERING INST CANCER ;UNIV COLUMBIA (US)) 30 November 1995 (1995-11-30) Claims 36-37; p. 4, l. 16-19; p. 10, l. 9-21; p. 11, l. 13-27; p. 48, l. 4-30; p. 58, l. 5-10; compound 55 Compound 57	1,3,5-9
X	US 4 279 836 A (NISHIKIDO JOJI ET AL) 21 July 1981 (1981-07-21) Claims 1; formulas (I), (II) and (VII); scheme col. 3-4 step (B)	1,6

☒ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

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Date of the actual completion of the international search

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European Patent Office, P.B. 5818 Patentlaan 2  
NL - 2280 HV Rijswijk  
Tel. (+31-70) 340-2040, Tx. 31 651 epo nl,  
Fax: (+31-70) 340-3016

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Rivat, C

## INTERNATIONAL SEARCH REPORT

Inte at Application No

PCT/EP 02/06488

## C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	RANADIVE V B ET AL: "NUCLEOPHILIC REACTIONS OF N-HYDROXY-, METHOXY-, 2,3-EPOXYPROPOXY-PHTHA LIMIDES" INDIAN JOURNAL OF CHEMISTRY, SECTION B: ORGANIC, INCL. MEDICINAL, PUBLICATIONS & INFORMATIONS DIRECTORATE, NEW DELHI, IN, vol. 12, no. 33B, December 1994 (1994-12), pages 1175-1177, XP001087547 ISSN: 0019-5103 Compounds 9a and 9b ---	1
X	KHAN, MOHAMMED NIYAZ: "The kinetics and mechanism of a highly efficient intramolecular nucleophilic reaction. The cyclization of ethyl N-[o-(N-hydroxycarbamoyl)benzoyl]carbamate to N-hydroxyphthalimide" J. CHEM. SOC., PERKIN TRANS. 2 (1988), (2), 213-19, XP001094387 Compound 5H on p. 214 ---	1
X	KOBASHI, KYOICHI ET AL: "Effect of acyl residues of hydroxamic acids on urease inhibition" BIOCHIM. BIOPHYS. ACTA (1971), 227(2), 429-41, XP001094532 p. 433, last paragraph; Table II, second last compound ---	1
Y	EP 0 847 992 A (MITSUI CHEMICALS INC) 17 June 1998 (1998-06-17) Claims 1, 3, 12, 21-23; formula (1); table 1, compounds 8-9, 78-80, 166-167, 185; table 2, compound 20 ---	1,3,5-9
Y	WO 01 38322 A (METHYLGENE INC) 31 May 2001 (2001-05-31) Claims 1-2, 6, 36, 39; formula (1); ex. 8, 21-28; compounds 148-153; table 4, ex. 21-28, 36 (148-153), compounds 172-173, 177 -----	1,3,5-9

# INTERNATIONAL SEARCH REPORT

International application No.  
PCT/EP 02/06488

## Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This International Search Report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:  
because they relate to subject matter not required to be searched by this Authority, namely:
2. ☐ Claims Nos.:  
because they relate to parts of the International Application that do not comply with the prescribed requirements to such an extent that no meaningful International Search can be carried out, specifically:
3. ☐ Claims Nos.:  
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

## Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this International Search Report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this International Search Report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this International Search Report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

1 (part), 3 (part), 5-9 (all in part)

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest.
- ☐ No protest accompanied the payment of additional search fees.



INTERNATIONAL SEARCH REPORT

International application No.

PCT/EP 02/06488

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. Claims: 1 (part), 3 ( part), 5-9 (all in part)

Hydroxamic acid derivatives of amido-phenyl as HDAC inhibitors

2. Claims: 1 (part), 2, 3 ( part), 4, 5-9 (all in part)

Hydroxamic acid derivatives of amido-thiophene as HDAC inhibitors

# INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No  
PCT/EP 02/06488

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 9531977 A	30-11-1995	US 5700811 A AU 692561 B AU 2647495 A CA 2190765 A EP 0760657 A	23-12-1997 11-06-1998 18-12-1995 30-11-1995 12-03-1997
US 4279836 A	21-07-1981	JP 1125620 C JP 54148743 A JP 57020300 B CH 641763 A DE 2919160 A FR 2425428 A GB 2020653 A,B GB 2094294 A,B IT 1166794 B	30-11-1982 21-11-1979 27-04-1982 15-03-1984 15-11-1979 07-12-1979 21-11-1979 15-09-1982 06-05-1987
EP 0847992 A	17-06-1998	JP 3354090 B JP 10152462 A JP 2002332267 A US 6174905 B	09-12-2002 09-06-1998 22-11-2002 16-01-2001
WO 0138322 A	31-05-2001	AU 1876801 A EP 1233958 A	04-06-2001 28-08-2002